

# SPREAD-SPECTRUM COMMUNICATION METHOD AND APPARATUS

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### Description of the Related Art

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guard time (GT).

A receiving end which receives the data bursts uses the synchronization code in the preamble period to perform reproduction of a carrier, input of automatic gain control (AGC), establishment of clock synchronization, and so forth. The receiving end further detects the unique word (UW) and the station-identification code (ID), and when it perceives that the successive data (DA) is desired data addressed to itself, it holds a reproduced carrier, AGC, clock synchronization and so forth until the data terminates, and it demodulates the data.

However, this communication method causes an error in the reference clock frequency between the transmitting and receiving ends. Thus, with the lapse of time, the receiving end's clock which has held the established synchronization in the preamble, also has increased synchronization errors with respect to the transmitting end's clock. In addition, for example, if the transmission line is wireless, communication quality may vary with time, which results in the possibility of the input AGC held in the preamble losing its optimum condition with the lapse of time. According to this communication method, the maximum time during which data can be transmitted with one data burst is limited by the time during which synchronization precision, AGC precision and so forth can be maintained.

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According to the above communication method, when a large amount of digital data (e.g., image data or the like) adapted for recent multimedia applications is transmitted, as shown in Fig. 2, data is divided into a plurality of portions, and the complete data must be transmitted as a plurality of data bursts. As a result, the preamble time and the guard time with respect to the time used for transmission of the actual data increases, and there is the possibility of an interrupting burst from another station occurring between the divided data bursts. Consequently, the data throughput deteriorates.

In order to extend the maximum time during which the data can be transmitted with one data burst, a precise frequency oscillator, and a complicated synchronization circuit or AGC must be used, which disadvantageously requires an expensive, large-sized apparatus.

#### SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide a spread-spectrum communication method and apparatus having a high throughput.

It is another object of the present invention to provide a spread-spectrum communication method and apparatus adapted for performing large-amount data communication.

It is a further object of the present invention to

provide a spread-spectrum communication method and apparatus in which an adjustment period for receiving spread spectrum data is provided in a period for transmitting spread spectrum data.

5           It is a still further object of the present invention to provide a spread-spectrum communication method and apparatus which communicate an adjustment signal for adjusting reception of spread spectrum data in a plurality of divided data-communication periods.

10           Other objects of the present invention will be apparent from the embodiments described below, based on the attached drawings.

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15           To this end, according to a first aspect of the present invention, the foregoing objects have been achieved through provision of a spread spectrum communication method comprising the steps of: dividing a communication period for spread spectrum data into a plurality of communication periods; and providing an adjustment period for receiving the spread spectrum data between one data-communication  
20           period and another data-communication period.

          The spread spectrum communication method may further comprise the step of synchronizing a spread code in the adjustment period.

25           The spread spectrum communication method may further comprise the step of providing the adjustment period prior

5           The spread spectrum communication method may further  
comprise the step of holding gain in the data-communication  
period.

          The spread spectrum communication method may further  
comprise the step of communicating code-division-multiplexed  
10 data in the data-communication period.

          The spectrum communication method further comprising  
the step of providing the adjustment period prior to the  
plurality of data-communication periods, may still further  
comprise the steps of establishing the setting of a  
15 receiving end in the adjustment period prior to the  
plurality of data communication periods; and correcting the  
established setting in the adjustment period between one  
data-communication period and the next data-communication  
period.

20           Preferably, in the spread spectrum communication method  
further comprising the step of providing the adjustment  
period prior to the plurality of data-communication periods,  
the gain for the adjustment in the adjustment period prior  
to the plurality of data-communication periods is larger  
25 than the gain for the adjustment in the adjustment period

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Fig. 7 is a flowchart showing a case where a mid-amble is being received in the first embodiment of the present invention.

Fig. 8 is a chart showing the format of data bursts in a second embodiment of the present invention.

Fig. 9 is a flowchart showing a case where a mid-amble is being received in the second embodiment of the present invention.

Fig. 10 is a chart showing the format of data bursts according to a third embodiment of the present invention.

Fig. 11 is a flowchart showing a case where a preamble is being received in the third embodiment of the present invention.

Fig. 12 is a flowchart showing a case where a mid-amble is being received in the third embodiment of the present invention.

Fig. 13 is a chart showing the format of data bursts according to a fourth embodiment of the present invention.

#### DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 3 shows the format of a data burst according to a first embodiment of a digital communication method of the present invention. For example, the data burst having a train-type data-burst structure includes a preamble (PR), data (DA) and one or a plurality of what will, hereinafter,

5     The mid-amble (MD) includes a synchronization code (SY).

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of the AGC by the high-frequency processor 43 in step S32,  
fine phase adjustment of the clock signal by the  
synchronizer 44A in step S33, and so forth. An upper layer  
45 informs the timing generator 44F whether the data has  
5 terminated or whether a following mid-amble has been  
received, in step S31. Since acquisition of the clock  
synchronization and the AGC has been established in the  
preamble (PR) period, the clock synchronization in the mid-  
amble (MD) period is sufficiently achieved by only phase  
10 correction, and the initial acquisition of the AGC is not  
needed. Accordingly, the synchronization code in the mid-  
amble (MD) period may be shorter than the synchronization  
code in preamble (PR) period. The high-frequency processor  
43 increases the gain to cause the rapid acquisition of the  
15 AGC in step S13, and decreases the gain to perform fine  
adjustment of the AGC in step S16 or S32. After the lapse  
of a predetermined time, the timing generator 44F holds the  
AGC and the clock synchronization by the high-frequency  
processor 43 and the synchronization unit 44 in step S36,  
20 and causes an SS demodulator 44C to demodulate the data (DA)  
in step S215. The receiving end performs the above  
processes until the train terminates.

In this manner, according to the first embodiment, even  
when a large amount of digital data is sent, the data can be  
25 transmitted without separating it into a plurality of data

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[bursts. In this case the need for a plurality of conventionally required unique words (UW), station-identification codes (ID) and guard times (GT) is eliminated, and there is no possibility that interrupting  
5 bursts from another station occur. Consequently, improving the data throughput itself is realized.]

Fig. 8 shows the format of a data burst according to a second embodiment of the present invention.

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10 The data burst according to the second embodiment has a train-type data-burst structure including a preamble (PR), data (DA) and one or a plurality of mid-ambles (MD). The preamble (PR) includes a synchronization code (SY), a unique word (UW) and a station-identification code (ID). Each mid-  
15 ambler includes a synchronization code (SY) and a unique word (UW).

The structure used with this format is identical to that shown in Figs. 4A, 4B, 5A and 5B.

Fig. 9 shows a flowchart of the operation of the receiving end in handling such a data burst, and in  
20 particular, the mid-ambler (MD). The operation of the receiving end while receiving the preamble (PR) is identical to that shown in Fig. 6.

In a case where there are successive groups of data (DA), when the synchronization code (SY) of the mid-ambler  
25 (MD) is received in step S31, the high-frequency processor

Therefore, even when a large amount of digital data is sent, the need for a plurality of conventionally required station-identification codes (ID) and guard times (GT) is eliminated, and there is no possibility that interrupting bursts from another station occur. Consequently, improving

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The receiving end which received the data burst causes the data processor 44 to establish synchronization by means

of the high-frequency processor 43 shown in Fig. 5A and to demodulate the data. In the data processor 44, a demodulation clock signal with synchronization established in the synchronization code (SY) period is used to perform reverse spread demodulation in the SS demodulator 44C, and the comparator 44E compares the signal series of "0101..." generated from the UW generator 44D and the demodulated data. If the output data of the SS demodulator 44C coincides with the unique word (UW) from the UW generator 44D, the timing generator 44F generates each predetermined timing included in the data burst, and sends the information data (DA), the station-identification code (ID), the status (ST) and so forth to the upper layer 45.

Figs. 11 and 12 show flowcharts of the operation of the receiving end when processing the above-described data burst. In an initial condition the timing generator 44F sets the selector 44G to the UW generator 44D. When the data burst is received, in step S52 the AGC is acquired by the high-frequency processor 43 and the clock synchronization is established by the synchronizer 44A in accordance with the synchronization code. Successively, when the unique word (UW) is detected by the comparator 44E in step S53, the timing generator 44F performs setting so that in step S54 the high-frequency processor 43 and the synchronizer 44A hold the AGC and the clock synchronization.

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The timing generator 44F also sets the selector 44G to the ID generator 44B. In addition, when the comparator 44E detects that the station-identification code (ID) received in step S57 is addressed to the receiving end (i.e., to this particular receiver), the timing generator 44F recognizes the status input from the SS demodulator 44C in the subsequent step S58. The SS demodulator 44C demodulates the data in step S59, and performs setting so that the demodulated data is output to the upper layer 45 until it detects the end of the data in step S60.

The length and number of the groups of data (DA) are included in the status (ST) recognized in step S58. The timing generator 44F controls the reception sequence, based on them.

In addition, by sending the status (ST) to the upper layer 45, notification of the end of the data and the end of the train may be given from the upper layer 45.

If in step S61 the end of the train is not detected, or when a mid-ambly (MD) and data group (DA) are received after reception of a preceding data group (DA), the previously established AGC and synchronization held in steps S52 and S54 are adjusted in step S71 in accordance with the synchronization code (SY) of the mid-ambly (MD). When the unique word (UW) of the mid-ambly (MD) is detected in step S72, the AGC, the synchronization and so forth are held in

step S73, the process returns to step S59. If the SS demodulator 44C detects the end of the train, the process returns to step S52. Also, if it is found in step S57 that the station-identification code (ID) detected by the SS demodulator 44C is not addressed to the receiving end, the process returns to step S52.

The acquisition of the clock synchronization and the AGC has been established in the preamble period. Thus, the clock synchronization in the mid-amble period is sufficiently achieved by only phase correction, and the need for the initial acquisition of the AGC is eliminated. Accordingly, the synchronization code (SY) in the mid-amble (MD) may be shorter than the synchronization code (SY) in the preamble (PR) period. The high-frequency processor 43 increases the gain in step S52 so that the AGC is rapidly acquired, and in step S71 the gain is reduced to precisely adjust the AGC. The synchronizer 44A increases the acquisition gain in step S52, and decreases it in step S71.

Fig. 13 shows the format of a data burst according to a fourth embodiment of the present invention.

The data burst shown in Fig. 13 includes a preamble (PR), data groups (DA) and one or a plurality of mid-ambles (MD). The preamble (PR) includes a synchronization code (SY), a unique word (UW), and a station-identification code (ID). The data (DA) is multiplexed by code division

multiplexing. Each mid-amble (MD) includes a  
synchronization code (SY). A CDM communication method,  
which is one spread-spectrum communication method used to  
improve data throughput, uses N mutually orthogonal codes to  
perform the frequency-axially spread multiplexing of data,  
and sends the multiplexed data.

According to the fourth embodiment, the SS modulator  
41E has a structure as shown in Fig. 4B, and performs the  
code division multiplexing (CDM) of the data burst by using  
the spread-spectrum (SS) communication method.

In addition, the SS modulator 44C has a structure as  
shown in Fig. 5B, and uses N mutually orthogonal PN codes to  
perform the CDM reverse spreading of the code-division-  
multiplexed data. (The structures shown in SS modulators 41E  
and 44C are well known in themselves and need not be  
described; nonetheless, some details are noted below) Here,  
as shown in Fig. 10, by using a signal which is not  
multiplexed as a code in the preamble and the mid-amble,  
power consumed by the preamble and the mid-amble can be  
increased N times power per data channel, which means that  
synchronization establishing and AGC inputting, need not be  
greatly affected by a change in the communication quality of  
the transmission line.

Other operations of the receiving end may be performed  
by the processes shown in Figs. 6, 7, 9, 11 and 12.

When a code-synchronous CDM communication method is used in the SS modulator 44E, the spread spectrum modulation and multiplexing (CDM) of the selector 41E output is performed using N mutually orthogonal PN (pseudo-noise) codes. In this case the modulator 41E selects a synchronization code  $PN_0$  from spread codes  $PN_0$  to  $PN_N$ , and outputs it as an SY code to the high-frequency processor 42, without performing the code division multiplexing of it.

The code-synchronous CDM communication method is a spread-spectrum communication method used to improve the data throughput, which uses N mutually orthogonal codes to perform the spread multiplexing of data onto a frequency, and sends the multiplexed data. When the data or the like formed by the CDM is received and demodulated, gain and synchronization are held by the receiving end.

The station-identification code (ID), the status (ST) and the unique word (UW) other than information data are transmitted using one spread code.

In the foregoing, although the present invention has been described based on the preferred embodiments thereof, the present invention is not limited to the structures of those embodiments but may be modified within the appended claims.